Project Title: Aquatic Microbots for Distributed Robotics

Principal Investigator: Hugh Crenshaw, Duke University

Co-principal Investigator: Charles Pell, Nekton Technologies, Inc.

Sponsoring Agency: Defense Advanced Research Projects Agency, Electronics Technology Office

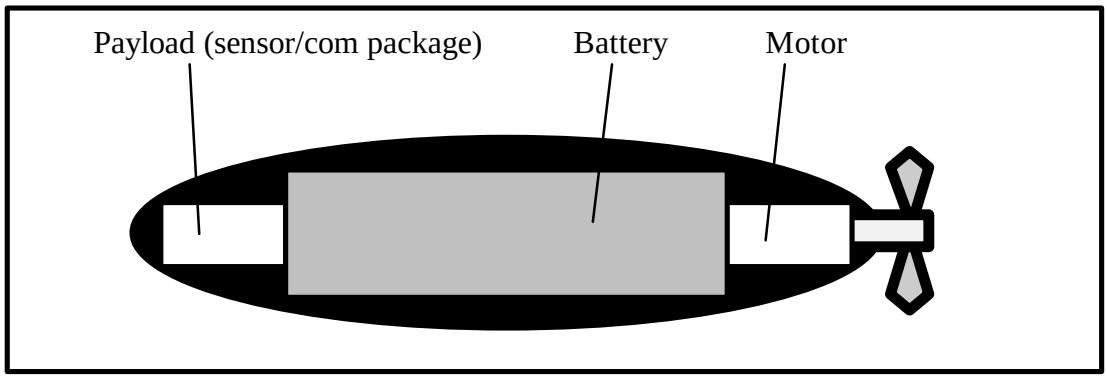

Figure 1. Nekton Technologies, MicroHunter microbotic submarine, 2X life size.

Duke University and Nekton Technologies have developed an extremely simple control system for steering a vehicle in 3D. With DARPA funding, we are now building small swimming robots, called MicroHunters™ (see figure 1) using this control system. MicroHunters™ are intended for deployment in large numbers for ocean survey, search, and sampling missions.

The primary advantages of MicroHunters™:

- Small (5-20 cm long – determined largely by the volume of the power source).
- Lightweight (as little as a few grams, i.e., their density equals the fluid).
- Simple (only 1 moving part; analog control circuits using a few components).
- Robust (able to operate in extremes of temperature and pressure).
- Fail-soft (they recover when knocked off course and tolerate damage).

Our current prototype microsubs have one moving part, are 20 cm long, 5 cm diameter, and cruise at 1 meter per second (2 knots) for 3 hours on one “AA” cell, giving a range of about 10 kilometers. This microsub will track a light source in 3D. Under our program, we are also developing very small (<5 cm, <5 grams) microsubs that cruise at a given depth and compass heading while logging temperature, conductivity, and other properties of interest. Swimming predefined transects, multiple robots can rapidly map large volumes of the water column. Conversely, MicroHunters™ can be deployed from and recalled to a base station (for instance, under the ice at the bottom of a bore hole), where they will provide continuous monitoring of the environment within a spherical volume equivalent to about half their maximum range. Recharging from a power source at this base station will permit MicroHunters™ to sortie repeatedly, allowing long-term monitoring.

We are examining MicroHunter™ communication via several modalities, including radio, optical, and acoustic signaling, depending on mission needs. We will develop communication between robots and simple reflex responses to enable emergent group behaviors in 3D. We want to conduct tasks more complex than transects, such as double-checking and identification of false signals or flexible redeployment in response to changing environmental parameters.

MicroHunter™ swarms will be most useful where other, larger systems are prone to failure. Complex, poorly known, or remote environments are ideal for a MicroHunter™ swarm: even if some are lost, others will succeed. Their small size is an advantage where mass and cost are constraints. This, their simplicity, and robust 3D navigation method make them ideal candidates for the Vostok and Europa missions.